PROTECTS*

*Program for Response Options and Technology Enhancements for Chemical/Biological Terrorism in Subways

Addressing a Critical Need

The March 1995 sarin attack in the Tokyo subway by a small group of extremists brought into sharp focus the vulnerability of U.S. subway systems to a similar chemical or biological (C/B) attack. The underground tunnel network of a subway system, with its moving trains and many ventilation shafts to the surface, can distribute a C/B agent throughout many stations and tunnels below ground and through ventilation shafts above ground to an entire city (see Fig. 1). Recent studies show that an incident involving anthrax can expose more than 100,000 people with an associated cost of more than 26 billion dollars.

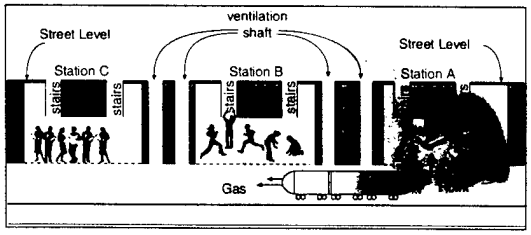

Figure 1. Sketch of Chemical Agent Release in Subway

Emergency-response exercises carried out after the Tokyo incident in New York City, Boston, and Washington, D.C., have revealed a critical need for improved planning and emergency response procedures to save lives in the event of a C/B attack. The knowledge needed by first responders as well as those involved throughout the subway system is lacking, as are the personal protection equipment and detection equipment needed to handle such an event. A modest investment in technology and advanced planning now can yield enormous benefits in the future.

Transit authorities need an *integrated* approach that covers preplanning for such incidents as well as emergency response during an event. PROTECTS is such a program, since it will develop new technology (hardware and software) and emergency planning recommendations before incidents occur and advanced emergency manage-ment tools for incident response. PROTECTS will provide this technical assistance and a practical approach for implementation to all U.S. subway systems.

A Cooperative Federal, State, and Local Program

The proposed program is envisioned as a cooperative effort among transit authorities, federal/state/local emergency response organizations, and government officials. Final products of this work cover the broad areas of engineering solutions to limit human and system impacts; tools and recommendations for emergency response and training; and methods for decontamination and recovery. Owing to the comprehensive nature of the program, PROTECTS will potentially include all key federal organizations with an active interest in this area, including the U.S. Department of Energy (DOE), Federal Transit Authority (FTA), U.S. Department of Defense (DOD), and Federal Emergency Management Agency (FEMA). The involvement of user groups at each stage of the program will ensure that the final products match the capabilities and requirements of the potential users. A close working relationship among project personnel, emergency response organizations, and transit authorities is essential to the success of the program.

PROTECTS is envisioned as a conceptual plan to prepare U.S. subway systems to better respond to C/B incidents. It is expected that PROTECTS would be administered by a multi-agency group.

Leveraging Ongoing Programs

PROTECTS is a natural outgrowth of ongoing programs sponsored by DOE, DOD, FTA, the U.S. Department of Transportation (DOT), FEMA, and existing transit authorities for responding to potential terrorist attacks and fires. In the area of modeling and simulation, DOT has supported years of development of the SES (Subway Environment Simulation) model that predicts air flow rates and cooling loads within a subway system as a function of time. Inflatable barrier studies such as those conducted by the Washington METRO (WMATA) provide a good point of departure for further work on containment strategies. The Technical Support Working Group (TSWG) of the Office of the Secretary of Defense is supporting an evaluation of the current generation of chemical sensors for possible use in subway stations. DOD and DOE have supported numerous long-term efforts related to C/B agent sensors, decontamination, dispersion modeling, and emergency response planning. PROTECTS builds on the successes of these past and current federal agency programs.

Elements of PROTECTS

Figure 2 shows the seven major elements of PROTECTS.

1. Modeling and Simulation

This element will identify the consequences of a range of scenarios that deal with releases in stations, train cars, and ventilation shafts. Predictions of transport and fate for this wide variety of scenarios will be used to identify the best mitigation and consequence management strategies in case of a terrorist incident. Modeling will also be used to study the effect of containment barriers and to define the proper operation and settings of ventilation fans to minimize the impacts on people both in the subway and above ground. The Washington METRO will serve as the initial study site; additional subway systems will be added as the study progresses so the effect of different subway system designs on the results will be fully considered.

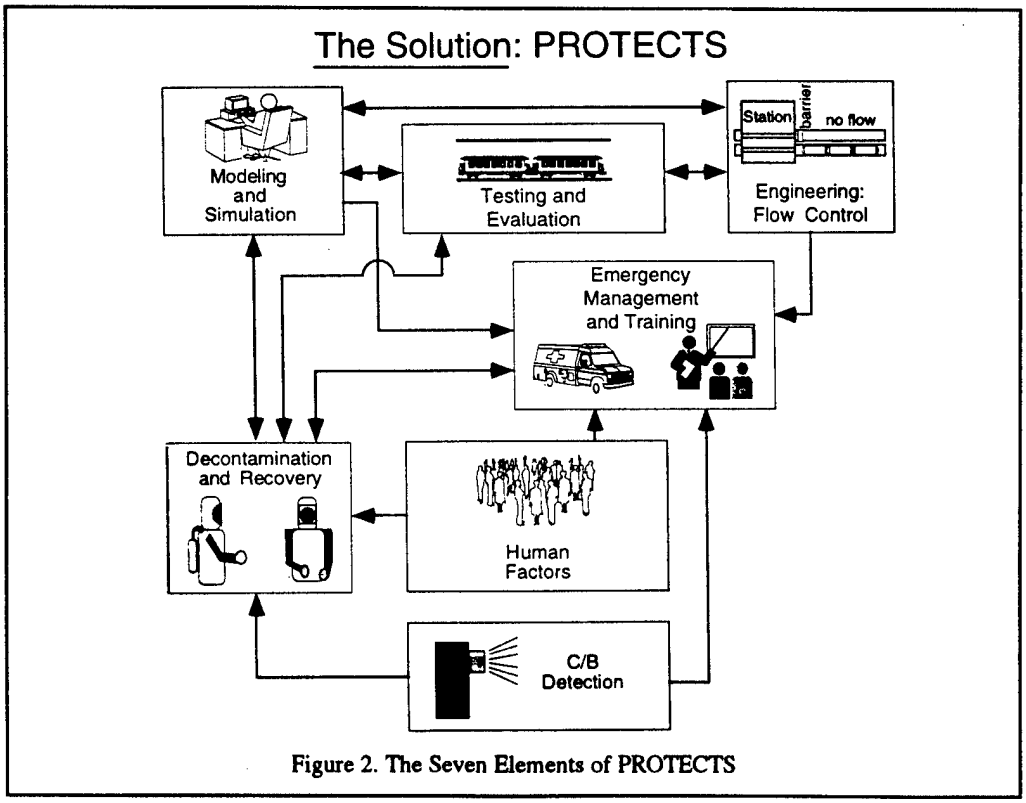

Figure 2. The Seven Elements of PROTECTS

2. Engineering – Flow Control

Mitigation options will be greatly enhanced if independent control of tunnel and station air flow patterns can be achieved. Allowing a C/B agent to spread unchecked throughout the entire subway system and ultimately to the surface can potentially expose large numbers of people. Ventilation control can be used to either confine the C/B agent plume to a particular section of tunnel or alternatively to disperse the plume as rapidly as possible. Much is known about ventilation techniques; much less is understood concerning flow control. The best option for a specific incident will depend on the location and nature of the release. Controlled ventilation can also be used to clear escape routes for passengers and access routes for emergency response personnel. Correct control modeling of ventilation flow within the subway system is the critical element in developing the most effective strategy for a particular event. This element evaluates and develops new methods for flow control in support of modeling recommendations mainly using new design and experimental techniques.

3. Testing and Evaluation

Because the results from both elements above may ultimately form the basis for significant upgrades to existing systems, both the accuracy of the analysis and the efficacy of the flow control system will need to be validated by field testing. Such tests will have to be conducted so as to have only a minimal impact on transit system operation. All dispersion testing will be done by using harmless simulants subject to authorization by the respective transit authority. The testing of decontamination methods with subway materials will be done in the laboratory.

4. Detection of Chemical and Biological Agents

Although work on new sensor technologies is progressing at a steady pace, electronic sensors of C/B agents are at an early stage of development and thus cannot be relied on at present for automated event detection. Despite this state of affairs, portable and fixed C/B sensors can be used to confirm an incident, identify the specific nature of the agent or agents being used, support mitigation actions, and aid in rescue operations. The combination of C/B sensors and real-time computer simulations can be a powerful tool for crisis management. A long-term program for protecting the nation's subway systems must include the ongoing consideration and evaluation of sensor options and factor in new sensor technologies as they become available. Until sensors are available and reliable, human observation and intelligence information will be used to identify an incident.

5. Human Factors

The human factors element of the proposed program involves determining how to best manage people and enable them to most efficiently communicate information during an emergency. Issues of concern include (a) how to best manage rider behavior, (b) how transit workers can best identify and report an incident most efficiently, (c) how to collect incident information and evidence in the most usable form for forensic and scientific evaluation, and (d) how riders can become alert observers for the transit authority without becoming alarmed. A related issue is how passengers can learn to take part in their own rescue.

6. Emergency Management and Training

This element involves the implementation of strategies developed from elements 1 through 5 above and includes (a) development of first responder procedures, (b) development of Operations Control Center protocols, and (c) coordination of rescue operations with city, state, and federal response organizations.

To aid transit authorities and response organizations in preparing emergency plans, a man-

ual that examines all issues relevant to C/B incidents will be developed. The manual will address initial incident identification through crisis management and ultimately postevent activities. Team scientists will partner with transit authorities and federal, state, and local agencies to assist them in developing appropriate emergency response protocols. In addition, responders will provide feedback to the team scientists to ensure that the manual meets their needs.

Technological solutions are only as good as the training provided on how to use them. Past fires in subway systems have revealed that inadequate training is the biggest impediment to proper emergency action. Poor emergency management outcomes are also caused by human error and the gap between high-technology solutions and the capability of transit workers to use them. Although technological solutions have often worked well, the inability of transit workers to effectively use the technologies has been problematic. The integration of response options and technological solutions into transit system operations involves the training of and exercises by (a) subway workers; (b) emergency response workers; (c) Operations and Control Center staff; (d) local, state, and federal agencies; and (e) public affairs and media personnel. Drills must take place regularly to refresh, reinforce, and update trainees on key concepts. Training materials and classes on the tools developed specifically for this program will be prepared. A team of technical staff will also provide broader guidance through workshops and reviews of in-house training programs, as needed.

Finally, a computer program will be developed as a training tool to show trainees how C/B agents disperse in s[illegible] and inform them about the outcomes of specific emergency response options.

7. Decontamination and Recovery

Studies will be carried out to evaluate the most effective methods for decontaminating subway tunnels and stations. Both agents contained in the air and agents deposited on surfaces will be considered. Procedures and equipment for such work will be identified for transit authority consideration. Laboratory studies will determine if the proposed methods will be sufficient for ensuring passenger safety on the basis of their proposed frequency and intensity of application. A protocol for sampling after cleanup is also needed to assure that decontamination has been successful and that it is safe for passengers to re-enter the subway. If available methods for decontamination are found to be inadequate, new approaches will be developed. This effort will be updated periodically to incorporate scientific advancements.

Two-Track Effort for Subway Systems

U.S. subway systems vary in terms of their (a) technology (old to modern systems), (b) mix of underground and aboveground sections, and (c) tunnel construction techniques. Most systems need to upgrade their emergency ventilation capabilities to meet current standards for fire and smoke incidents. This requirement provides an impetus for subway systems to research ways to meet both fire/smoke and C/B challenges by using compatible, cost-effective methods. Such methods do exist.

The U.S. subway systems can be placed into four categories on the basis of the character of their ventilation systems and their likely need for different C/B solutions:

(1) "modern" (e.g., Atlanta, Los Angeles, Buffalo)
(2) "newer" (e.g., Washington, D.C., San Francisco)
(3) "old but upgrading" (e.g., Boston, parts of NYC), and
(4) "old" (e.g., Chicago, Philadelphia, Newark, parts of NYC).

A representative system from each of these categories will be studied to determine general principles for preplanning, mitigation, and emergency response.

WMATA, the Washington METRO, is

identified for a fast-track effort since it is the most vulnerable target politically and has been at the forefront of both fire/smoke mitigation and C/B protection efforts. Such efforts have focused on inflatable barriers for fire/smoke applications, and that flow control option is being considered again for both fire/smoke and C/B protection.

Once the approach to the seven elements is defined for any of the four prototypes, technologies will be immediately transferred to similar systems in the same category. However, some refinements will probably be required to account for site-specific details of design and operation.

Three-Phase Program and End Products

The PROTECTS program schedule (Figure 3) shows the time each of the four characteristic subway systems will be studied. In addition, a general study of subway systems assessment, characterization, and analysis will be conducted starting in the first year; it will include all elements and subway systems. This work will identify general trends and principles as quickly as possible to allow development of emergency response plans on the basis of the best scientific information available at that time. That general task will continue in Years 2-5.

Phase I (Year 1) work will concentrate on providing interim guidance for each element for each of the four subway system categories on the basis of available information and modeling work done in that first year. Phase II (Year 2) will enhance the guidance of Phase I on the basis of what can be done in Year 2. Any technological breakthroughs in Years 1 and 2 will be incorporated as they occur. Phase III work (Years 3-5) will represent progress for all elements and subway systems (incremental to Phase II) for which technology improvements are needed in most elemental areas. The PROTECTS program will provide more advanced recommendations in each of the seven elements at the end of each of the five years for all subway systems.

To apply the technologies and lessons learned to all subway systems at the earliest time, three demonstrations are planned. At the end of both Year 1 and Year 2, a demonstration of the operation of the advanced technology and emergency response capability for one subway system will be presented. At the end of Year 5, a similar demonstration for a different system is planned.

The major end products of this program will be:

1. Technical tools for planning and developing emergency response strat-

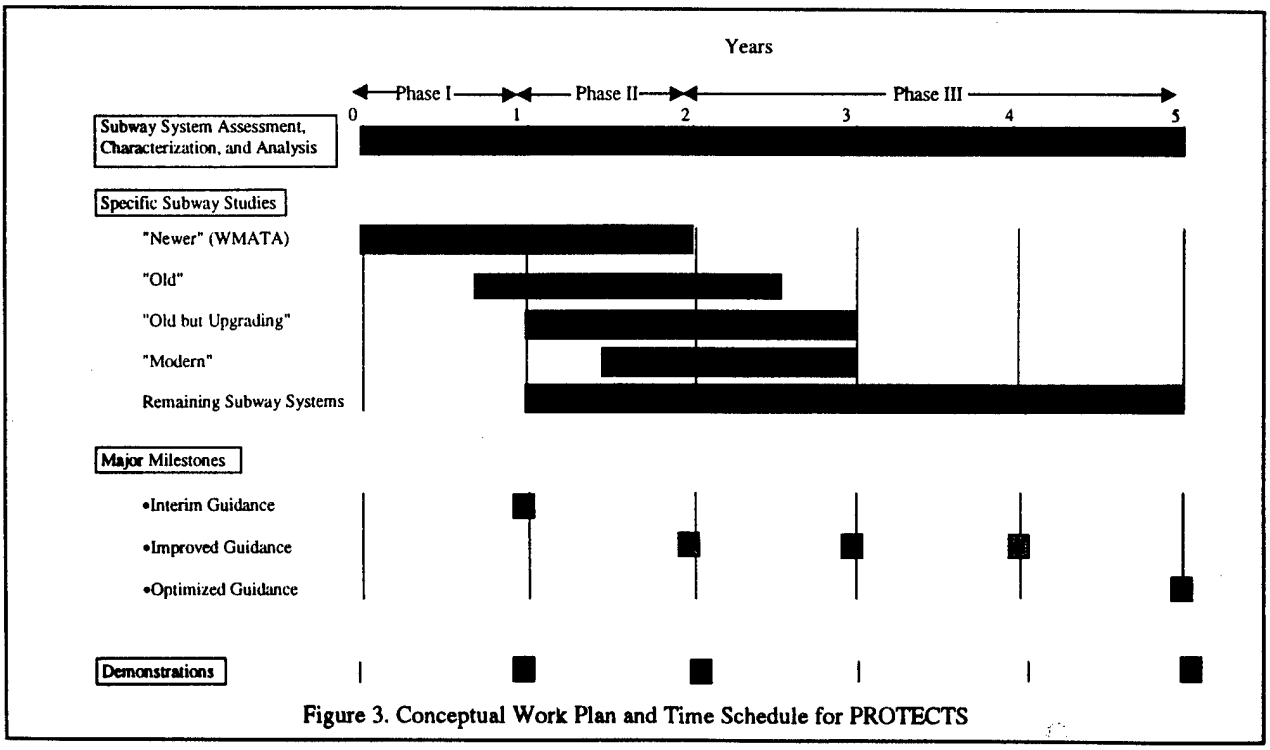

Figure 3. Conceptual Work Plan and Time Schedule for PROTECTS

egies,

2. Recommendations of engineering solutions that will limit adverse impacts and protect both emergency responders and the general public,
3. Manuals for developing emergency procedures that will mitigate consequences and thus save lives during and immediately following an incident,
4. Technical assistance in implementing the program through training and exercises, and
5. Determination of methods and procedures for subway decontamination, recovery, and disruption minimization.